MODIS Snow Products User Guide for Collection 4 Data Products

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Revised January 2003

Introduction

The MODIS snow products are created as a sequence of products beginning with a swath (scene) and progressing, through spatial and temporal transformations, to an eight-day global gridded product. The algorithms and data content of these snow products are briefly described in this guide with the purpose of providing a user with sufficient information about the content and structure of the data files to enable the user to access and use the data. Overviews of the file format and sequence of MODIS snow products are given first. Descriptions of each algorithm and product content are given in following sections. World Wide Web sites and documents related to the snow products are listed in the last two sections.

File Format of Snow Products

The MODIS snow products are archived in Hierarchical Data Format - Earth Observing System (HDF-EOS)

format files. [HDF](#), developed by the National Center for Supercomputing Applications (NCSA), is the standard archive format for EOS Data Information System (EOSDIS) products. The snow product files contain global attributes (metadata) and scientific data sets (SDSs) (data arrays) with local attributes. Unique in HDF-EOS data files is the use of HDF features to create point, swath, and grid structures to support geolocation of data. These structures (Vgroups and Vdata) provide geolocation relationships between data in a SDS and geographic coordinates (latitude and longitude or map projections) to support mapping the data. Attributes (metadata), global and local, provide various information about the data. Users unfamiliar with HDF and HDF-EOS formats may wish to consult Web sites listed in the [Related Web Sites](#) section for more information.

Snow data product files contain three EOS Data Information System (EOSDIS) Core System (ECS) global attributes also referred to as metadata by ECS. These ECS global attributes; *CoreMetadata.0*, *ArchiveMetadata.0* and *StructMetadata.0* contain information relevant to production, archiving, user services, geolocation and analysis of data. The ECS global attributes are written in parameter value language (PVL) and are stored as a character string. Metadata and values are stored as objects within the PVL string. Results of the snow algorithms, e.g. snow cover, are stored as SDSs with local attributes. Local attributes may include summary statistics and other information about the data in a SDS, e.g. snow-covered area, percent of cloud, or a key to data values. Detailed descriptions of each snow product are given in following sections.

Products may also contain product specific attributes (PSAs) defined by the product developers as part of the ECS *CoreMetadata.0* attribute. Geolocation and gridding relationships between HDF-EOS point, swath, and grid structures and the data are contained in the ECS global attribute, *StructuralMetadata.0*.

A separate file containing metadata will accompany data products ordered from a DAAC. That metadata file will have a ".met" extension and is written in PVL. The .met file contains some of the same metadata as in the product file but also has other information regarding archiving and user support services as well as some post production quality assurance (QA) information relevant to the granule ordered. The post production QA metadata may or may not be present depending on whether or not the data granule has been investigated. The ".met" file should be examined to determine if postproduction QA has been applied to the granule. (The Quality Assurance sections of this guide provide information on postproduction QA.)

The data products were generated in the ECS science data production system using the HDF-EOS toolkit, Science Data Processing (SDP) Toolkit, HDF API and the C programming language. Various software packages, commercial and public domain, are capable of accessing the HDF-EOS files.

Sequence of Snow Products

Snow data products are produced as a series of six products. The sequence begins as a swath (scene) at a nominal pixel spatial resolution of 500 m and a nominal swath coverage of 2330 km (across track) by 2030 km (along track, about five minutes of MODIS scans). A summarized listing of the sequence of products is given in Table 1. Products in EOSDIS are labeled as Earth Science Data Type (ESDT), the ESDT label "ShortName" is used to identify the snow data products. Except for the initial snow product, MOD10_L2, each snow product in the sequence is produced using the preceding snow product as input. Product levels in EOSDIS identify these snow products and indicate what spatial and temporal processing has been applied to the data.

Data product levels briefly described: Level 1B (L1B) is a swath (scene) of MODIS data geolocated to latitude and longitude centers of 1 km resolution pixels. A level 2 (L2) product is a geophysical product that remains in latitude and longitude orientation of L1B. A level 2 gridded (L2G) product is in a gridded format of a map projection. At L2G the data products are referred to as tiles, each tile being a piece, e.g. 10° x 10° area, of a map projection. L2 data products are gridded into L2G tiles by mapping the L2 pixels into cells of a tile in the map projection grid. The L2G algorithm creates a gridded product necessary for the level 3 products. A level 3 (L3) product is a geophysical product that has been temporally and or spatially manipulated, and is in a gridded map

projection format and comes as a tile of the global grid.

Brief descriptions of the snow data products are given here to give perspective to the sequence. Expanded descriptions of the snow products are given in following sections.

The first product, MOD10_L2, is a snow cover map at 500 m spatial resolution for a swath. The snow map is the result of the algorithm identifying snow and other features in the scene. Geolocation data (latitude and longitude) at 5 km resolution is stored in the product. The second product, MOD10L2G, is a multidimensional data product created by mapping the pixels from the MOD10_L2 granules for a day to their Earth locations on the sinusoidal map projection, thus multiple observations, i.e. pixels, covering a geographic location (cell) in the tile are "stacked" on one another. Information on the pixels mapped into a cell is stored in pointer and geolocation products associated with the L2G product. The third product, MOD10A1, is a tile of daily snow cover at 500 m spatial resolution. The daily observation that is selected from multiple observations in a MOD10L2G cell is selected using a scoring algorithm. The fourth product, MOD10C1, is a daily global snow cover map in a geographic map projection. It is created by assembling MOD10A1 daily tiles and binning the 500 m cell observations to the 0.05° spatial resolution of the Climate Modeling Grid (CMG) cells. The fifth product, MOD10A2, is an eight-day composite of snow cover. It is made by compositing from two to eight days of the MOD10A1 product. The sixth product, MOD10C2, is an eight-day composite of snow cover at the same resolution as MOD10C1. It is made by compositing the MOD10A2 product.

Table 1. Summary of the MODIS snow data products.

Earth Science Data Type (ESDT)	Product Level	Nominal Data Array Dimensions	Spatial Resolution	Temporal Resolution	Map Projection
MOD10_L2	L2	1354 km by 2000 km	500m	swath (scene)	None. (lat,lon referenced)
MOD10L2G	L2G	1200km by 1200km	500m	day of multiple coincident swaths	Sinusoidal
MOD10A1	L3	1200km by 1200km	500m	day	Sinusoidal
MOD10A2	L3	1200km by 1200km	500m	eight days	Sinusoidal
MOD10C1	L3	360° by 180° (global)	0.05° by 0.05°	day	Geographic
MOD10C2	L3	360° by 180° (global)	0.05° by 0.05°	eight days	Geographic

MOD10_L2 Snow Product

This product is generated using the MODIS calibrated radiance data products (MOD02HKM and MOD021KM), the geolocation product (MOD03), and the cloud mask product (MOD35_L2) as inputs. The MODIS snow algorithm output (MOD10_L2) contains two SDS of snow cover, each using a different cloud mask, a quality assurance (QA) SDS, latitude and longitude SDSs, local attributes and global attributes. The snow cover

algorithm identifies snow-covered land; it also identifies snow-covered ice on inland water. There are approximately 288 swaths of Terra orbits acquired in daylight so there are approximately 288 MOD10_L2 snow products per day.

An example of the MOD10_L2 product shown as a colorized snow cover map is exhibited at the MOD10_L2 webpage.

Algorithm Description

A brief sketch of the snow algorithm is given here for the purpose of aiding the user in understanding and interpreting the data product. The snow algorithm is described in detail in the Algorithm Theoretical Basis Document.

Analysis for snow in a MODIS swath is constrained to pixels that:
1. have nominal Level 1B radiance data
2. are on land or inland water
3. are in daylight
4. are unobstructed by clouds (two separate criteria are applied)
5. have an estimated surface temperature less than 283K

The constraints are applied in the order listed. After these constraints are applied, only pixels having a daylight clear sky view of land surface are analyzed for snow. Data inputs to the snow algorithm are listed in Table 2.

Clouds are masked using data from the MODIS Cloud Mask data product (MOD35_L2). The MOD35_L2 data is checked to determine if the cloud mask algorithm was applied to a pixel. If it was applied then results of the cloud mask algorithm are used. If it was not applied then the cloud mask is not used, the snow spatial QA bit 5 is set to indicate that the cloud mask was not used, and the snow algorithm will process for snow assuming that the pixel is unobstructed by cloud. Initially only the summary cloud result, the unobstructed field-of-view flag, from MOD35_L2 was used to mask clouds from the snow algorithm. Subsequent investigation has resulted in an alternative way to mask clouds using results of specific cloud tests from MOD35_L2.

Investigative research on the MOD35_L2 cloud-clearing algorithm revealed that a more liberal cloud mask for the purpose of snow mapping could be created by selective use of certain cloud spectral tests results and reflectance characteristics. Four criteria determine the liberal cloud mask:
1. cloud if the CO2 cloud test reports clouds (stored at bit14)
2. cloud if the cloud brightness temperature difference test reports cloud (stored at bit19)
3. cloud if the visible reflectance test reports cloud (stored at bit 20) and band 6 reflectance > 0.2 and that the confidence in the bit20 test was high.

The liberal cloud mask reduces cloud obscuration by allowing for analysis of snow in pixels that are contaminated with translucent or very thin clouds. Also, in some situations the MOD35_L2 algorithm identifies snow as clouds, which precluded mapping of that snow by the snow algorithm using only the unobstructed field-of-view flag. Use of the liberal cloud mask alleviates much of that problem. An advantage of this liberal cloud mask is that it allows for snow analysis on more pixels and often result in increased accuracy of snow mapping in regions were there is snow and a mix of snow and clouds or false identification of snow as cloud. A disadvantage of this liberal cloud mask is that some types of ice clouds are falsely identified as snow. The user is advised to be aware of this condition when using the snow cover data with the liberal cloud mask. When snow is expected it may be advantageous to use the snow cover SDS with the liberal cloud mask. During the summer or in regions where snow is not expected then it may be advantageous to use the conservative cloud mask. Investigation on how to alleviate the snow confusion with ice clouds when using the liberal cloud mask approach continues.

Initial processing through Collection 3, ECS Version 3, used only the unobstructed field-of-view flag from MOD35_L2. For Collection 4, ECS Version 4, a subset of cloud spectral tests results from MOD35_L2 were used to generate a second cloud mask, described above as the liberal cloud mask, within the snow algorithm. The standard cloud mask is used to produce the snow map in the "Snow Cover" SDS and the liberal cloud mask is used to produce the snow map in the "Snow Cover Reduced Cloud" SDS. Only the "Snow Cover" SDS is passed to the higher level products.

Masking of oceans and inland waters is done with the 1 km resolution land/water mask, contained in the MODIS geolocation product (MOD03). The 1 km data of the land/water mask is applied to the four corresponding 500m pixels in the snow algorithm. Ocean waters are not analyzed for snow. Inland waters are analyzed for the condition of snow-covered inland waters, primarily lakes.

Table 2. MODIS data product inputs to the MODIS snow algorithm.

ESDT	Long Name	Data Used
MOD02HKM	MODIS Level 1B Calibrated and Geolocated Radiances	Reflectances for MODIS bands: 1 (0.645 μm) 2 (0.865 μm) 4 (0.555 μm) 6 (1.640 μm)
MOD021KM		31 (11.28 μm) 32 (12.27 μm)
MOD03	MODIS Geolocation	Land/Water Mask Solar Zenith Angles Sensor Zenith Angles Latitude Longitude
MOD35_L2	MODIS Cloud Mask	Cloud Mask Flag Unobstructed Field of View Flag Various cloud test results Day/Night Flag

The MODIS L1B is screened for missing data and for unusable data. Unusable data results from the processing at L1B when the sensor radiance data fails to meet acceptable criteria. MODIS data may be unusable for several reasons. Specifics of L1B processing and criteria can be found at the MCST web page and in supporting documentation. If missing data is encountered those pixels are identified as missing data in MOD10_L2. If unusable data is encountered then a no decision result is written for those pixels. Usable L1B calibrated radiance data is converted to at-satellite reflectance for use in the snow algorithm.

Snow detection is achieved through the use of two groups of grouped criteria tests for snow reflectance characteristics in the visible and near-infrared regions. One group is for detection of snow in many conditions. Criteria for snow in that group of tests is that a pixel has a normalized snow difference index (NDSI), ((band 4-band 6) / (band 4 + band 6)) greater than 0.4 and near-infrared reflectance (band 2) greater than 0.11 and band 4 reflectance greater than 0.10. If a pixel passes this group of criteria tests it is identified as snow in the data product. The other group of criteria tests is used to better detect snow in dense vegetation. In this other group, if a pixel has NDSI and NDVI ((band 2-band 1) / (band 2+band 1)) values in a defined polygon of a scatter plot of the two indices and near-infrared reflectance in band 2 greater than 0.11 and band 1 reflectance greater than 0.1, it is also determined to be snow. This group is applied without regard to the ecosystem. Snow-covered ice on

inland water is determined by applying the first group of criteria tests used for snow detection to pixels mapped as inland water by the land-water mask.

Intermediate checks for theoretical bounding of reflectance data and the NDSI ratio are made in the algorithm. In theory, reflectance values should lie within the 0-100% range and the NDSI ratio should lie within the -1.0 to +1.0 range. Summary statistics are kept within the algorithm for pixels that exceed these theoretical limits; however, the test for snow is done regardless of violations of these limits. These violations suggest that error or other anomalies may have crept into the input data and indicate that further investigation may be warranted to uncover the causes. Those summary statistics have an affect on the setting of the various quality assurance metadata objects in the product.

A basic assumption is made that all the input data products will be available and that the quality of the data will be acceptable. That assumption may be violated, occasionally, so catches for anomalous data have been, and are being built into the algorithm during testing. Possibly the most common anomaly is that some input data, e.g. a few lines of MODIS data, are missing or that some detectors on the MODIS sensor are dead. In the case of missing data, the snow algorithm identifies the data as missing in the output product. No action is taken in the algorithm to make an analysis for missing data. In the case of dead detectors, the MOD02HKM algorithm writes the average radiance value of the pixels in the proceeding and succeeding lines to the dead detector pixel. Pixels of dead detectors are flagged in the snow spatial SDS by setting bit 2 to on to indicate that averaged data was used. If other anomalous conditions occur in the input data, the snow algorithm makes no decision for that pixel, except for some expected anomalous conditions where a value indicating the source of the anomaly is written, and moves to the next pixel. A summary statistic for invalid data conditions is reported as a local attribute.

Scientific Data Sets

Results of the snow algorithm are stored as coded integers in the "Snow Cover" and "Snow Cover Reduced Cloud" SDSs of the HDF-EOS product file. The snow algorithm identifies pixels as being snow, snow-covered lake ice, cloud, land, water, or other condition. The conditions identified by the algorithm are listed in Table 3. Table 3 is the interpretation key to the coded integers, and is stored as the local attribute "Key:". A color-coded image of the snow algorithm result for a swath of MODIS data is shown in the MOD10_L2 product webpage.

Table 3. Interpretation key for MOD10_L2 snow product.

Integer Value	Meaning
255	Fill Data--no data expected for pixel
254	Saturated MODIS sensor detector
200	Snow
100	Snow-Covered Lake Ice
50	Cloud Obscured
39	Ocean
37	Inland Water
25	Land--no snow detected
11	Darkness, terminator or polar
1	No Decision

0	Sensor Data Missing

Coarse resolution (5 km) latitude and longitude data for geolocating the snow data are located in the "Latitude" and "Longitude" SDSs. The latitude and longitude data correspond to a center pixel of a 5 km by 5 km block of pixels in the "Snow Cover" SDS. The mapping relationship of geolocation data to the snow data is specified in the global attribute *StructMetadata.0*. Mapping relationship was created by the HDF-EOS SDPTK toolkit during production. Geolocation data is mapped to the snow data with an offset = 5 and increment = 10. The first element (1,1) in the geolocation SDSs corresponds to element (5,5) in "Snow Cover" SDS; the algorithm then increments by 10 in the cross-track or along-track direction to map geolocation data to the "Snow Cover" SDS elements.

A quality assurance (QA) SDS that indicates the quality of the algorithm result for a pixel is also written. Description of the QA SDS is given in the Quality Assurance sub-section.

Local Attributes

Archived with the "Snow Cover" SDS are local attributes that describe the data and provide summary data on the results of the snow cover algorithm. HDF predefined local attributes (Table 4) describe characteristics of the data, and custom local attributes (Table 5) provide summary information on snow cover. Some software packages make use of the standardized HDF-predefined local attributes. An exception in the use of HDF-predefined local attributes is that "Calibration" is not used because the snow data are not stored in calibrated format.

Table 4. HDF-predefined local attributes for SDSs in snow product.

Attribute Name	Reserved Label(s)	Definition	Sample Value
Label	long_name	Long Name of the SDS	Snow_covered_land
Unit	units	SI units of the data, if any	none
Format	format	How the data should be viewed, Fortran format notation	I3
Coordinate System	coordsys	Coordinate system to use for the data	latitude, longitude
Range	valid_range	Max and min values within a selected data range	0-254
Fill Value	Fill_Value	Data used to fill gaps in the swath	255
Calibration	scale_factor scale_factor_err add_offset add_offset_err calibrated_nt	not used	not used

Custom local attributes for the "Snow Cover" SDS are listed and described in Table 5.

Table 5. Local Attributes for the snow SDS

Attribute Name	Definition	Sample Value
Key:	Key to meaning of data in the SDS	*see Table 3*

Valid EV Obs Band 1 (%)	The percentage of valid observations from Level 1B in Band 1 in the swath. (0.0-100.0)	100.0
Valid EV Obs Band 2 (%)	The percentage of valid observations from Level 1B in Band 2 in the swath. (0.0-100.0)	100.0
Valid EV Obs Band 4 (%)	The percentage of valid observations from Level 1B in Band 4 in the swath. (0.0-100.0)	100.0
Valid EV Obs Band 6 (%)	The percentage of valid observations from Level 1B in Band 6 in the swath. (0.0-100.0)	100.0
Saturated EV Obs Band 1 (%)	The percentage of saturated observations from Level 1B in Band 1 in the swath. (0.0-100.0)	0.342
Saturated EV Obs Band 2 (%)	The percentage of Saturated observations from Level 1B in Band 2 in the swath. (0.0-100.0)	0.287
Saturated EV Obs Band 4 (%)	The percentage of saturated observations from Level 1B in Band 4 in the swath. (0.0-100.0)	0.779
Saturated EV Obs Band 6 (%)	The percentage of saturated observations from Level 1B in Band 6 in the swath. (0.0-100.0)	0.698
Auto_check_QA	If all the data and intermediate calculations did not exceed a 15% limit of anomalous conditions, the snow cover algorithm result is considered acceptable; otherwise, it is questionable.	"Acceptable"

Global Attributes

There are eight global attributes, three ECS: *CoreMetadata.0*, *ArchiveMetadata.0*, and *StructMetadata.0*; and seven product unique attributes in the MOD10_L2 data product. Contents of these global attributes were determined and written during generation of the product and are used in archiving and populating the EOSDIS database to support user services. They are stored as very long character strings in parameter value language (PVL) format. Descriptions of the global attributes are given here to assist the user in understanding them.

CoreMetadata.0 is the global attribute in which information compiled about the product during product generation is archived and was used to populate the EOSDIS database to support user services. The content of the global attributes with sample values and comment of definition are listed in Table 6, Table 7, and Table 8 (respectively.) The seven product unique attributes are given in Table 9. The user wanting detailed explanations of the global attributes and related information should query the EOSDIS related web sites.

Table 6. Listing of objects in the global attribute *CoreMetadata.0* in MOD10_L2.

Object Name	Sample Value	Comment
LocalGranuleID	"MOD10_L2...hdf"	Filename
ProductionDateTime	"2002-07-16T05:52:31.000Z"	Date and time the file was produced.
DayNightFlag	"Day"	Snow will have either Day or Both.

ReprocessingActual	"reprocessed"	
LocalVersionID	"SCF V4.0.0"	Version of algorithm delivered from the SCF.
ReprocessingPlanned	"further update is anticipated"	Expect that products will be reprocessed several times.
ScienceQualityFlag	"Not being investigated"	Set by snow investigator after post- production investigation
AutomaticQualityFlagExplanation	"No errors detected in processing"	Explanation of result of automated QA checks made during execution.
AutomaticQualityFlag	"Passed"	Result of automated checks during the run of the algorithm that screen for significant amounts of anomalous data.
ScienceQualityFlagExplanation	"See http://..."	URL where science QA status is posted.
QAPercentMissingData	0	Range of 0-100
QAPercentCloudCover	43	Range of 0-100
ParameterName	"Snow Cover"	QA parameters are given for the snow cover data.
EquatorCrossingDate	"2001-07-12"	
EquatorCrossingTime	"17:43:04.827021"	
OrbitNumber	8335	
EquatorCrossingLongitude	-106.330685	
VersionID	4	ECS Version
ShortName	"MOD10_L2"	ESDT name of product
InputPointer	("MOD02HKM...hdf, MOD..."	Names of input files.
GringPointLongitude	[67.769638, 104.349876, 93.029350, 66.612961]	

GringPointLatitude	[57.728020, 52.490131, 36.089413, 39.877670]	
GringPointSequenceNo	[1,2,3,4]	
ExclusionGRingFlag	"N"	
RangeBeginningDate	"2001-07-12"	Beginning and ending times of the first and last scan line in the swath.
RangeBeginningTime	"17:25:00.000000"	
RangeEndingDate	"2001-02-12"	
RangeEndingTime	"17:30:00.000000"	
PGEVersion	"2.0.0"	Version of production generation executable.
AncillaryInputPointer	"MOD03...hdf"	Name of the geolocation file
AncillaryInputType	"Geolocation"	Type of ancillary data referenced by pointer.
AssociatedSensorShortName	"MODIS"	
AssociatedPlatformShortName	"Terra"	
AssociatedInstrumentShortName	"MODIS"	
Product Specific Attributes (PSA)		
QAPERCENTGOODQUALITY	68	Summary quality assurance statistic for data product. Range of 0-100.
QAPERCENTOTHERQUALITY	0	
QAPERCENTNOTPRODUCEDCLOUD	32	
QAPERCENTNOTPRODUCEDOTHER	2	
GRANULENUMBER	211	Unique granule identifier
SNOWCOVERPERCENT	0	Summary percentage of snow-covered land.
CLOUDPERCENT	43	Summary percentage of cloud obscured land.

The ECS global attribute *ArchiveMetadata.0* contains information relevant to production of the data product. It also contains an alternate bounding of geographic coverage of the swath. These data may be useful in determining what version of the algorithm was used to generate the product. Contents are described in Table 7.

Table 7. Listing of objects in the global attribute *ArchiveMetadata.0* in MOD10_L2.

Object Name	Typical Value	Comment
AlgorithmPackageAcceptanceDate	"2002-04-25"	Algorithm Descriptors
AlgorithmPackageMaturityCode	"OPL"	
AlgorithmPackageName	"MOD_PR10 revised with two cloud mask applications"	
AlgorithmPackageVersion	"Version 4.0.0.0"	
LongName	"MODS/Terra Snow Cover 5-Min L2 Swath 500m"	
InstrumentName	"Moderate-Resolution Imaging SpectroRadiometer"	
LocalInputGranuleID	("MOD021KM..., MOD35...")	Names of input files.
Processing Center	"MODAPS"	
Processing Environment	"IRIX64"	UNIX or Linux
ProcessingDateTime	"2002-07-16T05:52:31.000Z"	
SPSOParameters	"none"	
EastBoundingCoordinate	-64.276869	Extent of swath coverage, in latitude and longitude.
WestBoundingCoordinate	-109.799949	
NorthBoundingCoordinate	66.304428	
SouthBoundingCoordinate	44.034017	
DESCRRevision	"4.0"	Descriptor file version

The *StructMetadata.0* global attribute is used by the HDF-EOS toolkit to specify the mapping relationships between the geolocation data and the snow cover data (SDSs). Mapping relationships are unique in HDF-EOS and are stored in the product using HDF structures. Description of the mapping relationships is not given here. Use of HDF-EOS toolkit, other EOSDIS supplied toolkits, or other software packages may be used to geolocate the data.

Table 8. Listing of objects in the global attribute *StructMetadata.0* in MOD10_L2.

Object	Definition
DIMENSION_1	Along_swath_lines_500m
DIMENSION_2	Cross_swath_pixels_500m
DIMENSION_3	Coarse_swath_lines_5km
DIMENSION_4	Coarse_swath_pixels_5km

DIMENSIONMAP_1	GeoDimension=Coarse_swath_pixels_5km DataDimension=Cross_swath_pixels_500m Offset=5 Increment=10
DIMENSIONMAP_2	GeoDimension=Coarse_swath_lines_5km DataDimension=Along_swath_lines_500m Offset=5 Increment=10
GEOFIELD_1	GeoFieldName=Latitude
GEOFIELD_2	GeoFieldName=Longitude
DATAFIELD_1	DataFieldName=Snow Cover
DATAFIELD_2	DataFieldName=Snow Cover PixelQA
DATAFIELD_3	DataFieldName=Snow Cover Reduced Cloud

Table 9. MOD10_L2 product specific global attributes.

Attribute Name	Sample Value	Comment
HDFEOSVersion	"HDFEOS_V2.4"	Version of HDF_EOS toolkit.
L1BcalibrationQuality	"marginal"	A general quality indicator of MODIS data.
L1BmissionPhase	"A&E"	
L1BnadirPointing	"Yes"	
L1BversionID	"2000-02-24"	Version of the L1B processing algorithm.
SCF Algorithm Version	"$Id: MOD_PR10_AA…"	Internal SCF version.
Surface_Temperature_Screen_Threshold	283.0	

Quality Assurance

Indicators of quality are given in metadata objects in the *CoreMetadata.0* global attribute and in a quality assurance (QA) SDS, generated during production, or in post-product scientific and quality checks of the data product. QA metadata objects in the *CoreMetadata.0* global attribute are the AutomaticQualityFlag and the ScienceQualityFlag and their corresponding explanations AutomaticQualityFlagExplanation and ScienceQualityFlagExplanation. The AutomaticQualityFlag is set according to rules based on data conditions encountered during a run of the snow algorithm. Setting of this QA flag is fully automated. The rules used to set it are liberal; nearly all of the data or intermediate calculations would have to be anomalous for it to be set to "Failed". Typically, it will be set to "Passed" or "Suspect". "Suspect" means that a significant percentage of the data was found to be anomalous and that further analysis should be done to determine the source of anomalies. The AutomaticQualityFlagExplanation will contain a brief message relevant to the reason for the setting of the AutomaticQualityFlag. The ScienceQualityFlag and ScienceQualityFlagExplanation are set post production

either after an automated QA program is run on the data product or after the data product is inspected by a qualified snow investigator. Content and explanation of this flag are dynamic so it should <u>always</u> be examined if present. A sampling of products will be inspected. Random sampling or support of specific events such as field campaigns or snow events may be done.

The QA SDS in the data product provides additional information on algorithm results for each pixel. The QA SDS data are stored as bit flags in the SDS. This QA information can be extracted by reading the bits of the byte. The purpose of the QA SDS is to give the user information on algorithm results for each pixel that can be viewed in a spatial context. The QA information tells if algorithm results were nominal, abnormal, or if other defined conditions were encountered for a pixel. The QA information should be used to help determine the usefulness of the snow cover data for a user's needs. Predefined HDF local attributes for the QA SDS are listed in Table 4 and the custom local attributes are listed in Table 10. Summary local attributes in Table 10 are based on the total count of the pixels within a swath.

Table 10. Definitions of the Custom Quality Assurance Local Attributes.

Attribute Name	Definition
Nominal_results (%)	Percentage of pixels for which algorithm execution was nominal.
Abnormal_results (%)	Percentage of pixels for which algorithm execution encountered conditions outside of nominal range.
Cloud_obscured (%)	Percentage of pixels that were identified as cloudy.
Invalid_input (%)	Percentage of invalid L1B input data.
Key:	Description of the bit settings.

The snow cover QA SDS corresponding to the image on the MOD10_L2 web page is also shown there. Shown are bit masks of the pixels that had nominal QA, were cloud obscured, or for which abnormal conditions were detected.

The first two bits (0&1, read bit order as 76543210) in the QA SDS provide information on the general quality of the product. Those first two bits have a common meaning among products from the MODIS land discipline group. The remaining six bits are unique to the snow product. The local attribute "Key:" describes the setting and meaning of a bit. Conditions flagged by these bits in the MOD10_L2 product are:

Bit Description

2. Flags the occurrence of dead detectors in MODIS bands used in the snow algorithm. In the case of dead detectors an averaged data value from MOD02HKM is used and this bit is set to ON indicating that an averaged data value was used. If bit is set to OFF a nominal data value was used.

3. Flags pixels that were viewed at sensor view angles greater than 45 degrees. If the bit is set to ON then the observation of that pixel was greater than 45 degrees. Range scan angles is then 45 – 55 degrees. If the bit is set to OFF then the observation was within 45 degrees of nadir. Range of san angles is 0 – 45 degrees.

4. Flags occurrences of highly uncertain MODIS band 6 radiance calculalations from MOD02HKM algorithm. If the bit is set to ON then there was great uncertainty in its calculation. If the bit is set to OFF the uncertainty of calculation is much less uncertain.

5. Flags pixels where the cloud mask (MOD35_L2) was not determined. If the cloud mask was not

determined the snow algorithm processes assuming clear view condition. If the bit is set to ON the cloud mask was not determined, i.e. not used. If the bit is set to OFF the cloud mask was used.

6. Flags the occurrence of noisy MOD02HKM data. If any of the MODIS bands used in the snow algorithm were flagged as noisy in the MOD02HKM data then that flag setting is transferred to this bit. Noisy implies that there is more than a surface signal in the data. If this bit is set to ON then one or more MODIS bands of input data were reported as noisy. If this bit is set to OFF the input data was nominal.

7. Flags the occurrence of unusable MOD02HKM data. The MOD02HKM algorithm flags data as unusable for several know reasons or for unknown reasons. If unusable data is encountered the snow algorithm produces a no decision result and this bit is set to ON to indicate that the MOD02HKM data was unusable. If the bit is set to OFF the data is nominal.

MOD10_L2G Snow Product

The L2G product is the result of mapping all the MOD10_L2 swaths acquired during a day to grid cells of a map projection. Projection used for the snow cover products is the Sinusoidal projection. The MOD10_L2G product is a necessary intermediate product used as input to the daily snow cover product MOD10A1. The MOD10_L2G products are not archived at the DAAC and are not available for order through ECS.

In Collection 3 the Integerized Sinusoidal map projection was used. The Integerized Sinusoidal projection is a grid based on a sinusoidal map projection on which an adjustment to the angular width of grid cells is calculated for each latitudinal row of the grid so that there are an integral number of cells covering the entire 360 degrees in the latitudinal band. Differences between the Sinusoidal and Integerized Sinusoidal are minimal. A user probably will not notice any differences in a projected image. Many software packages support the Sinusoidal projection; few supported the Integerized Sinusoidal map projection.

Some references relevant to the Sinusoidal and Integerized Sinusoidal projections can be found in the Related Documents section of this guide.

Algorithm Description

The MODL2G algorithm was created as a generic gridding algorithm for many of the MODIS data products in the land discipline group, and was customized to each MODIS data product as necessary. See Wolfe *et al.* (1998) for a description of the gridding technique and product contents. The L2G algorithm maps pixels from the MOD10_L2 SDSs (snow and snow QA) into cells of the map grid. No calculations or analysis of snow cover is done at L2G.

Local Attributes

The predefined HDF local attributes (Table 4) and one custom local attribute (Nadir_resolution) exist for the SDSs in the L2G product. No summary statistics are generated.

Global Attributes

ECS global attributes of *CoreMetadata.0*, *ArchiveMetadata.0* and *StructMetadata.0* exist and have basically the same content as the MOD10_L2 product, though there is some variation.

Quality Assurance

Aside from QA indicating that the algorithm ran successfully, no automated QA analysis of the snow data is done in the algorithm.

MOD10A1 Daily Snow Cover

The daily Level 3 snow product is the result of selecting an observation from the multiple observations mapped to a cell of the MOD10_L2G product. The daily snow product is a tile of data gridded in the Sinusoidal projection. Tiles are approximately 1200 x 1200 km in area. A single SDS of snow cover and a single SDS of QA data along with local and global attributes compose the data product file.

Algorithm Description

The snow cover map for a day is constructed by examining the many observations acquired for a day mapped to cells of the grid by the L2G algorithm. A scoring algorithm is used to select an observation for the day. The scoring algorithm is based on location of pixel and solar elevation. Observations are scored based on distance from nadir, area of coverage in a grid cell and solar elevation. The object of the scoring is to select the observation nearest to nadir with greatest coverage at highest solar elevation angle that was mapped into the grid cell. Form of the scoring algorithm is;

$$score = 0.5 * (solar\ elevation) + 0.3 * (distance\ from\ nadir) + 0.2 * (observation\ coverage)$$

The relative view azimuth of the observation is also determined and if outside a set limit, a bit in the QA SDS is set to indicate that condition.

Results of the snow cover algorithm, a daily snow map of the region covered by the tile, are stored in the "Day_Tile_Snow_Cover" and per cell QA data for that snow map is stored in the "Snow_Spatial_QA" SDS. The snow cover data are stored as coded integer values, with values being the same as assigned in MOD10_L2.

An example of the MOD10A1 product for a tile of the Sinusoidal projection is shown on the MOD10A1 webpage. The names of the level 2 products mapped into the tile are given in the global attribute "MOD10InputGranuleNames" (Table 15).

Local Attributes

HDF predefined local attributes (Table 4) describe the structure and characteristics of the SDSs. Custom local attributes (Table 11) are used to provide summary information of snow cover and other features in the tile.

Table 11. Custom Local Attributes for the "Day_Tile_Snow_Cover" SDS

Attribute Name	Definition	Sample Value
missing_value	Coded integer used to indicate missing data	0
Snow_cover_pct (%)	Areal coverage of snow. (0-100)	68
Cloud_cover_pct (%)	Percentage of cloud in the tile. (0-100)	5
Land_area_pct (%)	Percentage of land in the tile. (0-100)	89

Key	Key to interpretation of coded integers.	"254=non-production mask, 200=snow, 100=lake_ice, 50=cloud_obscured, 39=ocean, 37=inland_water, 25=land, 11=night, 1=no_decision, 0=missing_data"

Global Attributes

Three ECS global attributes and eight product-specific global attributes are stored as metadata. The ECS global attributes, *CoreMetadata.0*, *ArchiveMetadata.0* and *StructMetadata.0* are stored as very long character strings in PVL format. Descriptions of the objects in these ECS global attributes and the product-specific global attributes are listed in Tables 11 – 14.

CoreMetadata.0 contains information about the product during production and is used to populate the EOSDIS database for user support. It also contains summarized QA information. A listing of objects along with sample values is given in Table 12.

Table 12. *CoreMetadata.0* of the MOD10A1 data product.

Object Name	Sample Value	Comment
LocalGranuleID	"MOD10A1...hdf"	File name
ProductionDateTime	"2002-07-27T08:52:55.000Z"	Date and time the file was produced.
DayNightFlag	"Day"	Snow will have either Day or Both.
ReprocessingActual	"reprocessed"	
LocalVersionID	"SCF V4.0.0"	Version of algorithm delivered from the SCF.
ReprocessingPlanned	"further update is anticipated"	Expect that products will be reprocessed several times.
ScienceQualityFlag	"Not being investigated"	Set by snow investigator after post-production investigation.
AutomaticQualityFlagExplanation	"No errors detected in processing"	Explanation of result of automated QA checks made during execution.
AutomaticQualityFlag	"Passed"	Result of automated checks during the run of the algorithm that screen for significant amounts of anomalous data.
ScienceQualityFlagExplanation	"See http://..."	URL where science QA status is posted.

QAPercentMissingData	<0/p>	Range of 0 – 100
QAPercentCloudCover	82	Range of 0 – 100
ParameterName	"Day_Tile_Snow Cover"	QA parameters are given for the snow cover data.
EquatorCrossingDate	"2002-01-27"	These objects are given for every MOD10A1 input file.
EquatorCrossingTime	"16:04:42.838607"	
OrbitNumber	11232	
EquatorCrossingLongitude	-83.178035	
VersionID	4	ESC Version
ShortName	"MOD10A1"	ESDT name of product
InputPointer	("MOD10L2G…hdf, MODPT...")	Names of input files.
GringPointLongitude	[-91.341614, -109.082617, -93.391716, -78.152820,]	
GringPointLatitude	[39.774875, 49.986349, 50.091897, 39.851060]	
GringPointSequenceNo	[1, 2, 3, 4]	
ExclusionGRingFlag	"N"	
RangeEndingDate	"2002-01-27"	Earliest beginning and latest ending times of the input granules.
RangeEndingTime	"19:10:00.000000"	
RangeBeginningDate	"2002-01-27"	
RangeBeginningTime	"15:50:00.000000"	
PGEVersion	"4.0.0"	Version of production generation executable.
AssociatedSensorShortName	"MODIS"	
AssociatedPlatformShortName	"Terra"	
AssociatedInstrumentShortName	"MODIS"	
Product Specific Attributes (PSA)		
QAPERCENTGOODQUALITY	18	Summary quality assurance statistic for data product. Range of 0 – 100%.
QAPERCENTOTHERQUALITY	82	
QAPERCENTNOTPROIDUCEDCLOUD	0	
QAPERCENTNOTPRODUCEDOTHER	0	
HORIZONTALTILENUMBER	11	

VERTICALTILENUMBER	04	
TILEID	"11011004"	Encoded tile ID. pshhhvvv where p-projection, s-size, hhh-horizontal tile number, vvv-vertical tile number.
SNOWCOVERPERCENT	4	Summary percentage of snow-covered land.

The ECS global attribute *ArchiveMetadata.0* contains information relevant to the input data, an alternate geographic coverage bounds, and information relevant to version of the algorithm and product. A listing of objects along with sample values is given in Table 13.

Table 13. Listing of objects in the global attribute ArchiveMetadata.0 in MOD10A1.

Object Name	Sample Value	Comment
CharacteristicBinAngularSize	15.000000	
CharacteristicBinSize	463.312717	
GEOAnyAbnormal	"False"	
GEOEstMaxRMSError	50.000	
DataColumns	2400	
DataRows	2400	
GlobalGridColumns	86400	
GlobalGridRows	43200	
AlgorithmPackageAcceptanceDate	"2002-05-00"	Algorithm Descriptors
AlgorithmPackageMaturityCode	"OPL"	
AlgorithmPackageName	"MOD10A1"	
AlgorithmPackageVersion	"Version 4.0.0.0"	
LongName	"MODIS/Terra Snow Cover Daily L3 Global 500m Sinusoidal Grid"	
InstrumentName	"Moderate-Resolution Imaging SpectroRadiometer"	
PlatformShortName	"Terra"	
LocalInputGranuleID	["MOD10L2G…,MODMG…"]	Names of input files.
ProcessingCenter	"MODAPS"	
ProcessingEnvironment	"IRIX64..."	UNIX or Linux
ProcessingDateTime	"2002-07-27T08:52:50.000Z"	

SPSOParameters	"none"	
NorthBoundingCoordinate	50.000000	Extent of swath coverage in latitude and longitude.
SouthBoundingCoordinate	40.000000	
EastBoundingCoordinate	-78.325905	
WestBoundingCoordinate	-108.898412	
DESCRRevision	"4.0"	Descriptor file version.

The *StructMetadata.0* global attribute is used by the HDF-EOS toolkit to create the mapping relationships between the defined grid and data (SDSs). Parameters of the projection are stored in *StructMetadata.0*.

Table 14. *StructMetadata.0* of the MOD10A1 data product.

Object Name	Sample Value
GRIDNAME	"MOD_Grid_Snow_500m"
PROJECTION	GCTP_SNSOID
DATAFIELD_1	"Day_Tile_Snow_Cover"
DATAFIELD_2	"Snow_Spatial_QA"

Other global attributes in the product are listed in Table 15.

Table 15. MOD10A1 product specific global attributes.

Attribute Name	Sample Value	Comment
HDFEOSVersion	"HDFEOS_V2.4"	Version of HDF_EOS toolkit.
L2GAutomaticQualityFlag	"Passed"	
L2GautomaticQualityFlagExplanation	"output file is created and good"	
L2GCoverageCalculationMethod	"area"	
L2GNumberOfOverlapGranules	2	Number of input granules with data falling in the tile.
L2GFirstLayerSelectionCriteria	"maximum observation coverage"	
MOD10InputGranuleNames	["MOD10_L2.A1999...", ...]	Listing of input files used to make the data product.
SCF Algorithm Version	"$Id: MOD_PR10A1_AA…"	Internal SCF version

Quality Assurance

Automated QA is applied to check that the MOD10_L2G input values are valid, i.e. one of the values in Table 3. Valid values are flagged as acceptable (nominal), invalid values are flagged as abnormal in the QA SDS. The predefined local attributes are the same as those in Table 4 and the custom local attributes are listed in Table 16.

To aid analysis of the data, QA bits are set to indicate where values outside nominal observation conditions were used. The algorithm processes data outside what is consider nominal observation conditions for a nominal result and sets a QA bit to indicate that outside of nominal range data was used. These bits are as follows.

Bit Description
2. Flags the occurrence of observations that lie in the viewing azimuth range of 150 – 210 degrees. If the bit is set to ON then the observation lies in that range. If the bit is set to OFF it is outside that range.
3. Flags the occurrence of observations in a cell that fall below the minimal coverage threshold of 20% considered to be considered a good observation. If the bit is set to ON the observation coverage was less than or equal to 20%. If the bit is set to OFF the observation coverage was greater than 20%.

Table 16. Definitions of the Custom Quality Assurance Local Attributes.

Attribute Name	Definition
Nominal_results (%)	Percentage of pixels for which algorithm execution was nominal.
Abnormal_results (%)	Percentage of pixels for which algorithm execution encountered conditions outside of nominal range.
Cloud_obscured (%)	Percentage of pixels that were identified as cloudy.
Invalid_input (%)	Percentage of invalid L1B input data.
Outside_relative_azimuth (%)	Percentage of pixels observed at a relative azimuth range of 150 – 210 degrees.
Key:	Description of the bit settings.

MOD10C1 Daily CMG Snow Product

The daily global climate modeling grid (CMG), a geographic projection, snow product gives a global view of snow cover at 0.05 degree resolution. Snow cover extent is mapped by processing the MOD10A1 products, approximately 320 tiles of land data, for a day into the CMG. Snow cover extent is expressed as a percentage of snow observed in the MOD10A1 cells at 500 m when mapped into a grid cell of the CMG at 0.05 degree resolution. Since the cells of the CMG contain mixed features an expression of confidence in the extent of snow is determined and stored as well as QA information.

Algorithm Description

A binning algorithm is used to calculate four parameters, snow cover, cloud cover, confidence index and quality assurance in a 0.05 degree CMG cell based on the 500 m MOD10A1 input data. The binning algorithm generates those parameters based the total number of observations of a class, e.g. snow, cloud, land, etc, and total number of land observations mapped into a cell of the CMG. Observations from all the input cells of the MOD10A1 tiles,

approximately 3600 per CMG cell at the equator, are put in observation bins. Calculated parameters are stored in four SDSs in the MOD10C1 product. The objective of the algorithm and resulting product is to provide the user an estimate of snow cover that was observed in a CMG cell along with an estimate of how much of the land surface was obscured by clouds and an index that estimates the confidence in the estimates.

The binning algorithm places the different classes of observations, e.g. snow, lake, cloud, etc into bins for each class. The MODIS snow algorithm at processing level 2 (MOD10_L2) analyzed all land pixels to determine if snow was present. Only land pixels were processed by use of the land water mask from the MOD03 product (see MOD10_L2 Snow Product section). A land bin is used to sum all the observations that were made on land, e.g. snow, land, cloud, etc. That sum of land counts is the basis for expressing the percentage of snow, cloud and the confidence index for each CMG cell. Because of the difference in resolution of the input data, 500m and the 0.05 degree resolution of the CMG cells, a CMG land mask was made for the algorithm. A 0.05 degree land mask was derived from the University of Maryland 1km global land cover data set (http://glcf.umiacs.umd.edu/data/landcover/index.shtml). If a CMG cell contains 12% or greater land then it is consider land and analyzed; if less than 12% it is considered ocean. That threshold was selected as a balance that minimized snow errors along coasts yet was sensitive to mapping snow along coasts.

The percentage of snow given in cells of the "Day_CMG_Snow_Cover" SDS is calculated using the 500m data totals of the number of snow observations and count of land observations in that cell for the day. Percentage of snow is then calculated as: percentage snow = 100 * count of snow observations/count of land.

Cloud percentage of a CMG cell is calculated in the same way as the percentage of snow except that count of cloud observations is used. The same calculation is used because only land cells, those as for snow calculation, are included in the calculation. Cloud percentage is stored in the "Day_CMG_Cloud_Obscured" SDS.

The confidence index was developed to provide users with an estimate of confidence in the data value reported for a cell. Confidence index values are stored in the "Day_CMG_Confidence_Index" SDS. Further explanation of the confidence index is given in the Scientific Data Sets section.

A quality flag for each CMG cell is set and reported in the "Snow _Spatial_QA" SDS. This quality flag is a summary representative of the quality of the MOD10A1 observations that were mapped into the CMG cell.

Night condition, polar darkness, is handled by determining the latitude of the CMG cell nearest the equator that is full of night observations. All CMG cells poleward from that latitude are mapped as night. Night was handled that way so that a neat demarcation of night and day is shown in the CMG.

Antarctica has been masked as perpetually snow covered. During the summer season some coastal regions, mainly the Antarctic Peninsula, may be snow free for a brief period of time.

A mask of where occurrence of snow is extremely unlikely, e.g. the Amazon, the Sahara, Great Sandy Desert, is applied at the end of the algorithm to eliminate erroneous snow occurrences. Source of erroneous snow is the MOD10_L2 product where false snow detection occurs and is carried forward through the processing levels. At the CMG level the use of this extremely unlikely snow mask eliminates erroneous snow from selected regions but will allow it in regions where snow may be a rare event.

Scientific Data Sets

Four SDSs are in the MOD10C1 product, "Day_CMG_Snow_Cover", "Day_CMG_Confidence_Index", "Day_CMG_Cloud _Obscured" and "Snow_Spatial_QA" are stored in the MOD10C1 product.

Percentage of snow-covered land based on the amount of clear sky view of all land in the CMG cell is given in the "Day_CMG_Snow_Cover" SDS. This is the amount of snow observed in the cell based on the cloud free observations mapped into the CMG grid cell for all land in the cell. No attempt was made to interpret snow cover

possibly obscured by cloud. Percentage of snow is reported in the range of 0-100%.

Data from the snow cover and cloud obscured SDSs can be used together to better understand the reported snow observation. For example, if a snow-covered region was viewed and no clouds obstructed the view on that day then percentage of snow cover would be 100%. If that snow-covered region was viewed but there was 30% cloud obscuration that day then percentage of snow cover would be 70%. A user could use the cloud obscured data from the "Day_CMG_Cloud _Obscured" SDS for the cell to determine that there was 30% cloud obscuration for that day. In the case of a partially snow-covered region where for example snow cover was 30% of the area for a day and no clouds obstructed the view then a value of 30% snow cover would be reported and the corresponding cloud obscuration would be 0%. Both the percent snow and percent cloud data could be used to better interpret the snow extent at the time.

Percentage cloud obscuration for a cell is given in the "Day_CMG_Cloud _Obscured" SDS. The percentage of cloud is the count of cloud observations for the day based on the total number of land cells in the grid cell. That is the same basis as used to calculate the percentage of snow. A cell may range from clear, 0% cloud to completely cloud obscured, 100% cloud.

An estimate of the confidence in the value determined for a cell is given in the "Day_CMG_Confidence_Index". This index indicates how confident the algorithm is that the snow percentage in a cell is correct based on data (snow, snow-free land, cloud, unknown) binned into the grid cell. A simplified example will be used to demonstrate the calculations for percent snow, percent cloud, and confidence index.

A 5km (0.5 degree) CMG grid cell has 50 500m observations, distributed as follows:
    snow observations: 20
    clear snow-free land observations: 15
    cloud obscured observations: 10
    uknown, but not water, observations: 5

    The percent snow is computed as:
    Snow% = 100 * (Number of snow observations) / (number of land and potential land observations)
    Snow% = 100 * 20 / (20 + 15 + 10 + 5)

    The percent cloud is computed as:
    Cloud% = 100 * (Number of cloud observations) / (number of land and potential land observations)
    Cloud% = 100 * 10 / (20 + 15 + 10 + 5)

    The confidence index (CI) is computed as:
    CI = 100 * (Number of clear land observations) / (number of land and potential land observations)
    CI = 100 * (20 + 15) / (20 + 15 + 10 + 5)

An assessment of the summary quality of the result for each cell is given in the "Snow_Spatial_QA" SDS. This is a two bit flag that indicates if the algorithm result is considered good quality, obscured by cloud, of questionable quality or if no result was reached. The key to this quality flag is given in Table 17.

Local Attributes

The predefined HDF local attributes (Table 4) are written to each SDS. Custom local attributes for the four SDSs are listed in Table 17.

Table 17. Custom Local Attributes for the "Day_CMG_Snow_Cover," "Day_CMG_Confidence_Index," "Day_CMG_Cloud_Obscured," "Snow_Spatial_QA," SDSs

Attribute Name	Definition	Sample Value
Day_CMG_Snow_Cover		
_MaskValue	Coded integer used to indicate areas of non-production.	254
_NightValue	Coded integer indicating night condition.	111
Cell_resolution	nominal size of CMG cell.	"0.05 deg"
Water_Mask_Pct_Land_Threshold	A cell with less land than this threshold is considered ocean.	12.00
Antarctica_snow_note		"Antarctica deliberately mapped as snow"
Day_CMG_Confidence_Index		
_MaskValue	Coded integer used to indicate areas of non-production	254
Cell_resolution	Nominal size of CMG cell	"0.05 deg"
Water_Mask_Pct_Land_Threshold	A cell with less land than this threshold is considered ocean.	12.00
Antarctica_CI_note		"Antarctica deliberately mapped as snow. CI set to 100."
Day_CMG_Cloud_Obscured		
_MaskValue	Coded integer used to indicate areas of non-production.	254
_NotProcessValue	Cell was not processed, applies to Antarctica.	252
_NightValue	Coded integer indicating night condition.	111
Cell_resolution	Nominal size of CMG cell.	"0.05 deg"
Water_Mask_Pct_Land_Threshold	A cell with less land than this threshold is considered ocean.	12.00

Antarctica_snow_note		"Antarctica deliberately mapped as snow. Cloud set to 252."
Snow_Spatial_QA		
key	Description of bit meanings	"state of bits: 00=nominal, 01=suspect, 10=cloud obscured, 11=not analyzed"
_MaskValue	Coded integer used to indicate areas of non-production.	254
Cell_resolution	Nominal size of CMG cell.	"0.05 deg"
Water_Mask_Pct_Land_Threshold	A cell with less land than this threshold is considered ocean.	12.00
Antarctica_QA_note		"Antarctica deliberately mapped as snow. Flag set to QAPERCENTNOTPRODUCEDOTHER."

Global Attributes

ECS global attributes of CoreMetadata.0, ArchiveMetadata.0 and StructMetadata.0 are listed in Tables 18, 19 and 20. Product specific global attributes are given in Table 20.

Table 18. CoreMetadata.0 of the MOD10C1 data product.

Object Name	Sample Value	Comment
LocalGranuleID	"MOD10C1...hdf"	Name of the granule.
ProductionDateTime	"2002-08-06T20:09:48.000Z"	Time granule was produced.
DayNightFlag	"Both"	
ReprocessingActual	"reprocessed"	Processed or reprocessed.
LocalVersionID	"SCF V4.0.0"	Version of algorithm delivered from the SCF.
ReprocessingPlanned	"further update is anticipated"	Expect that products will be reprocessed several times.
ScienceQualityFlag	"Not Investigated"	Science quality is determined post production.
AutomaticQualityFlag Explanation	"No errors detected in processing"	Explanation of result of automated QA checks made during execution.

AutomaticQualityFlag	"Passed"	Result of automated checks done on the data during a run of algorithm. Useful for screening for anomalous data.
ScienceQualityFlag Explanation	"See http://modland…."	URL for current information regarding science quality.
QAPercentMissingData	1	Range of 0 – 100
QAPercentCloudCover	5	Range of 0 – 100
ParameterName	"Global_Snow Cover"	Parameter for which QA statistics are given in this Metadata object.
VersionID	4	ESC Version
ShortName	"MOD10C1"	ESDT name of product
InputPointer	"MOD10A1.A2001193.h17v00..."	Listing of input file names.
EastBoundingCoordinate	180.000	
WestBoundingCoordinate	-180.000	
SouthBoundingCoordinate	-90.000	
NorthBoundingCoordinate	90.000	
ZoneIdentifier	"Other Grid System"	
RangeEndingDate	"2001-07-12"	
RangeEndingTime	"22:40:00.000000"	
RangeBeginningDate	"2001-07-12"	
RangeBeginningTime	"22:35:00.000000"	
PGEVersion	"4.0.0"	Version of PGE in MODAPS.
AssociatedSensorShortName	"MODIS"	
AssociatedPlatformShortName	"Terra"	
AssociatedInstrumentShortName	"MODIS"	
Product Specific Attributes (PSA)		
QAPERCENTGOODQUALITY	74	
QAPERCENTOTHERQUALTIY	1	Summary quality assurance statistic for data product. (0 – 100)
QAPERCENTNOTPRODUCEDCLOUD	25	

QAPERCENTNOTPRODUCEDOTHER	1	
SNOWCOVERPERCENT	15	Summary percentage of snow-covered land. (0-100)

Table 19. ArchiveMetadata.0 of the MOD10C1 data product.

Object Name	Sample Value	Comment
AlgorithmPackageAcceptanceDate	"08-05-2002"	Algorithm Descriptors
AlgorithmPackageMaturityCode	"OPL"	
AlgorithmPackageName	"MOD_PR10C1"	
AlgorithmPackageVersion	"Version 4.0.0"	
LongName	"MODIS/Terra Snow Cover Daily L3 Global 0.05Deg CMG"	
InstrumentName	"Moderate-Resolution Imaging SpectroRadiometer"	
PlatformShortName	"Terra"	
GlobalGridColumns	7200	
GlobalGridRows	3600	
ProcessingCenter	"MODAPS"	
ProcessingEnvironment	"IRIX 6.4"	UNIX or Linux environment
ProcessingDateTime	"2002-08-06T16:09:20.000Z"	
SPSOParameters	"none"	
DESCRRevison	"3.0"	Version of descriptor file.

Table 20. StructMetadata.0 of the MOD10C1 data product. Selected parts of StructMetadata.0 are listed here.

Object Name	Sample Value
GRIDNAME	"MOD_CMG_Snow_5km"
XDIM	7200
YDIM	3600
PROJECTION	GCTP_GEO
GRIDORIGIN	HDFE_GD_UL
DATAFIELD_1	"Day_CMG_Snow_Cover"
DATAFIELD_2	"Day_CMG_Confidence_Index"

DATAFIELD_3	"Day_CMG_Cloud_Obscured"
DATAFIELD_4	"Snow_Spatial_QA"

Table 21. MOD10C1 product specific global attributes.

Attribute Name	Sample Value	Comment
HDFEOSVersion	"HDFEOS_V2.4"	Version of HDF_EOS toolkit.

Quality Assurance

Automated QA done during a run of the algorithm checks that the input data is acceptable and that intermediate calculations were nominal. Results of QA are stored in some ECS global attributes. Per cell QA information is stored in the "Snow_Spatial_QA" SDS. Inclusion of more QA information is being investigated.

MOD10A2 Eight-day Snow Cover

An eight-day compositing period was chosen because that is the exact ground track repeat period of the Terra platform. Snow cover over eight days is mapped as maximum snow extent in one SDS and as a chronology of observations in the other SDS. Eight-day periods (Table 22) begin on the first day of the year and extend into the next year. The product can be produced with two to eight days of input. There may not always be eight days of input, because of various reasons, so the user should check the attributes to determine what days observations were obtained.

Table 22: Eight-Day Periods

Period No.	Year Days
1	1-8
2	9-16
3	17-24
4	25-32
5	33-40
6	41-48
7	49-56
8	57-64
9	65-72
10	73-80
11	81-88
12	89-96
13	97-104

14	105-112
15	113-120
16	121-128
17	129-136
18	137-144
19	145-152
20	153-160
21	161-168
22	169-176
23	177-184
24	185-192
25	193-200
26	201-208
27	209-216
28	217-224
29	225-232
30	233-240
31	241-248
32	249-256
33	257-264
34	265-272
35	273-280
36	281-288
37	289-296
38	297-304
39	305-312
40	313-320
41	321-328
42	329-336
43	337-344
44	345-352
45	353-360

46	361-368*

*Includes 2 or 3 days from next year, depending on leap year

Algorithm Description

The algorithm first checks that the input data, MOD10A1 files, are from the same eight-day period and orders them chronologically. The multiple days of observations for a cell are examined. If snow cover is found for any day then the cell in the "Maximum_Snow_Extent" SDS is labeled as snow. If no snow is found, but there is one value that occurs more than once, that value is placed in the cell (e.g. water on five days, cloud on one, land on one, and night on one, would be labeled water). Otherwise, if mixed observations occur, e.g. land and cloud over multiple days, the algorithm is biased to clear views in the period and will label a cell with what was observable. The logic minimizes cloud cover extent in that a cell would need to be cloud obscured for all days of observation to be labeled as cloud. If all the observations for a cell are analyzed but a result is not reached then that cell is labeled as no decision. A chronology of snow occurrence is recorded in the "Eight Day Snow Cover" SDS. On days that snow is found the bit corresponding to that day, eight-days across the byte from right to left, is set to on.

The algorithm will generate a product for any number of days from two to eight in the eight-day period. Sometimes all eight days of input may not be available due to data acquisition or production problems. The algorithm was designed to run will with fewer than eight days so that the data acquired could be processed even if one to six days of data is unavailable. Days used as input are identified in the global attributes.

Scientific Data Sets

Two SDSs exist in the product, "Maximum_Snow_Extent" and "Eight_Day_Snow_Cover". The maximum snow extent for the period is contained in the "Maximum_Snow_Extent" SDS that depicts where snow was observed on one or more days in the period. Days in the eight-day period when snow was observed are shown in the "Eight_Day_Snow_Cover" SDS. Input files are ordered chronologically in the algorithm and for days on which snow was observed a bit in the byte is set to on. Across a byte the days are ordered from right to left, bit 0 corresponds to day 1 of the eight-day period, bit 1 corresponds to day 2 of the eight-day period…bit 7 corresponds to day 8 of the eight-day period. If a bit setting of off could mean that data for that day was missing or that cloud was observed or that snow was not observed.

Local Attributes

HDF predefined local attributes (Table 4) describe the structure and characteristics of the SDSs. Custom local attributes (Tables 23 and 24) are used to provide summary information on snow cover and other features in the tile.

Table 23. Custom Local Attributes for the "Maximum_Snow_Extent" SDS

Attribute Name	Definition	Sample Value
Cell_area (km^2)	Nominal cell area.	0.21
Max_snow_area (km^2)	Estimated area covered by snow.	445772.2
Cloud_cover_area_pct (%)	Percentage of cloud in the tile.	5

| Land_area_pct (%) | Percentage of land in the tile. | 89 |
| Key | Key to interpretation of coded integers. | "200=snow, 100=lake ice, 50=cloud, 39=ocean, 37=inland water, 25=land, 11=night, 4=erroneous data, 1=missing data, 0=no decision" |

Table 24. Custom Local Attributes for the "Eight Day Snow Cover" SDS

Attribute Name	Definition	Sample Value
n_cells_8_snow	Count of cells with 8 days of snow	2076656
n_cells_8_mixed	Count of cells with mixed observations	5736916
n_cells_8_cloud	Count of cells with 8 days of cloud	476149
n_cells_8_fill	Count of cells with 8 days of fill	0
Key	Key to interpretation of bits.	"day1 in bit0….."

Global Attributes

ECS global attributes of *CoreMetadata.0*, *ArchiveMetadata.0* and *StructMetadata.0* are listed in Tables 25, 26, and 27. Product specific global attributes are given in Table 28.

Table 25. *CoreMetadata.0* of the MOD10A2 data product.

Object Name	Sample Value	Comment
LocalGranuleID	"MOD10A2...hdf"	File name
ProductionDateTime	"2002-10-02T18:36:48.000Z"	Date and time the file was produced.
DayNightFlag	"Day"	Snow will have either Day or Both.
ReprocessingActual	"reprocessed"	
LocalVersionID	"SCF V2.1.7"	Version of algorithm delivered from the SCF
ReprocessingPlanned	"further update is anticipated"	Expect that products will be reprocessed several times.
ScienceQualityFlag	"Not investigated"	Set by snow investigator after post-production investigation.
AutomaticQualityFlag Explanation	"No errors detected in processing"	Explanation of result of automated QA checks made during execution.

AutomaticQualityFlag	"Passed"	Result of automated checks during the run of the algorithm that screen for significant amounts of anomalous data.
ScienceQualityFlagExplanation	"See http://landdb1…"	URL where science QA status is posted.
QAPercentMissingData	0	Range of 0 - 100
QAPercentCloudCover	2	Range of 0 - 100
ParameterName	"Maximum Snow Extent"	QA parameters are given for the snow cover data.
VersionID	4	ESC Version
ShortName	"MOD10A2"	ESDT name of product
InputPointer	"MOD10A1...hdf..."	Names of input files.
GringPointLongitude	[-69.229489, -78.324437, -65.063518, -57.508571,]	
GringPointLatitude	[29.850609, 40.000000, 40.044675, 29.888344]	
GringPointSequenceNo	[1, 2, 3, 4]	
ExclusionGRingFlag	"N"	
RangeEndingDate	"2002-07-21"	Earliest beginning and latest ending times of the input granules.
RangeEndingTime	"16:50:00.000000"	
RangeBeginningDate	"2002-07-20"	
RangeBeginningTime	"14:25:00.000000"	
PGEVersion	"4.0.1"	Version of production generation executable.
AssociatedSensorShortName	"MODIS"	
AssociatedPlatform ShortName	"Terra"	
AssociatedInstrument ShortName	"MODIS"	
Product Specific Attributes (PSA)		
QAPERCENTGOODQUALITY	100	Summary quality assurance statistic for data product. Range of 0 – 100%.
QAPERCENTOTHERQUALITY	0	
QAPERCENTNOTPROIDUCEDCLOUD	0	
QAPERCENTNOTPRODUCEDOTHER	0	

HORIZONTALTILENUMBER	12	Horizontal position in Sinusoidal grid.
VERTICALTILENUMBER	05	Vertical position in Sinusoidal grid.
TILEID	51012005	Encoded tile ID. pshhhvvvp-projection, s-size, hhh-horizontal tile number, vvv-vertical tile number.
SNOWCOVERPERCENT	4	Summary percentage of snow-covered land.

The ECS global attribute *ArchiveMetadata.0* contains information relevant to the input data, an alternate geographic coverage bounds, and information relevant to version of the algorithm and product. A listing of objects along with sample values is given in Table 13.

Table 26. Listing of objects in the global attribute ArchiveMetadata.0 in MOD10A2.

Object Name	Sample Value	Comments
CharacteristicBinAngularSize	15.000000	
CharacteristicBinSize	463.312717	
DataColumns	2400	
DataRows	2400	
GlobalGridColumns	86400	
GlobalGridRows	43200	
AlgorithmPackageAcceptanceDate	"2002-05-00"	Algorithm Descriptors
AlgorithmPackageMaturityCode	"OPL"	
AlgorithmPackageName	"MOD10A2"	
AlgorithmPackageVersion	"Version 2.1.7"	
LongName	"MODIS/Terra Snow Cover 8-Day L3 Global 500m Sinusoidal Grid"	
InstrumentName	"Moderate-Resolution Imaging SpectroRadiometer"	
PlatformShortName	"Terra"	
LocalInputGranuleID	["MOD10A1…",…]	Names of input files.
ProcessingCenter	"MODAPS"	
ProcessingEnvironment	"IRIX64"	UNIX or Linux
ProcessingDateTime	"2002-10-02T18:36:44.000Z"	

SPSOParameters	"none"	
NorthBoundingCoordinate	40.000000	Extent of swath coverage, in latitude and longitude.
SouthBoundingCoordinate	30.000000	
EastBoundingCoordinate	-57.725404	
WestBoundingCoordinate	-78.324437	
DESCRRevision	"4.0"	Descriptor file version.

The *StructMetadata.0* global attribute is used by the HDF-EOS toolkit to create the mapping relationships between the defined grid and data (SDSs). Parameters of the projection are stored in *StructMetadata.0*.

Table 27. StructMetadata.0 of the MOD10A2 data product.

Object Name	Sample Value
GRIDNAME	"MOD_Grid_Snow_500m"
PROJECTION	GCTP_SNSOID
DATAFIELD_1	"Maximum_Snow_Cover"
DATAFIELD_2	"Eight_Day_Snow_Cover "

Other global attributes in the product are listed in Table 28.

Table 28. MOD10A2 product specific global attributes.

Attribute Name	Sample Value	Comment
HDFEOSVersion	"HDFEOS_V2.4"	Version of HDF_EOS toolkit.
Number of input days	1	Number of days input to the product. Range 2-8.
Days input	2002-201, 2002-202,…	Year days of input in chronological order.
Eight day period	2002-201, 2002-208	Days in the eight-day period. (See Table 21.)
SCF Algorithm Version	"$Id: MOD_PR10A1_AA…"	Internal SCF version

Quality Assurance

Rationales for setting the QA metadata objects and for setting the content of the spatial QA SDS are under development.

MOD10C2 Eight-Day Climate-Modeling Grid (CMG) Snow Product

The sequence of snow products ends with an eight-day climate-modeling grid (CMG) snow-cover data product. This product is generated by merging all the MOD10A2 products (tiles) for an eight-day period (Table 22) and binning that 500 m data to 1/20°, or about 5.6 km resolution to create a global CMG map of snow cover. Size of the arrays is 3600 rows by 7200 columns. Snow cover, cloud cover data and quality assurance information are included in the product.

Antarctica is arbitrarily mapped as always completely snow covered. Antarctica is 99% or greater snow covered. During the summer up to 1% may be snow-free mostly on the Antarctic Peninsula. That amount is less than the global error rate for snow mapping. Mapping Antarctica as always snow-covered was done to reduce confusion with clouds.

A land base map used in binning the MOD10A2 data was created from the University of Maryland 1 km global land cover mask (http://glcf.umiacs.umd.edu/data/landcover/index.shtml). The base land extent map indicates the amount of land in a CMG cell and is used to determine if the cell is processed for snow and is used in the calculation of the confidence index. A land percentage of 12% in a CMG cell is used as the threshold to determine that a cell is considered as land.

Night condition, polar darkness, is handled by determining the latitude of the CMG cell nearest the equator that is full of night observations. All CMG cells poleward from that latitude are mapped as night. Night was handled that way so that a neat demarcation of night and day is shown in the CMG.

A mask of where occurrence of snow is extremely unlikely, e.g. the Amazon, the Sahara, Great Sandy Desert, is applied at the end of the algorithm to eliminate erroneous snow occurrences. Source of erroneous snow is the MOD10_L2 product where false snow detection occurs and is carried forward through the processing levels. At the CMG level the use of this extremely unlikely snow mask eliminates erroneous snow from selected regions but will allow for snow detection in regions where snow may be a rare event.

Algorithm Description

The MOD10A2 data, 500 m resolution, are mapped into the corresponding cell of the CMG. Approximately 120 observations go into each CMG cell. Input values are binned into categories of snow, cloud, night, etc. The percentages of snow, percentage of cloud, QA and confidence index are computed, based on the binning results for each cell of the CMG, and written into the appropriate SDSs. The basis for the percentage calculations is the amount of land in that cell determined from the base land extent map.

There are four SDSs with local attributes and four global attributes written in the CMG product.

Scientific Data Sets

The "Eight_Day_CMG_Snow_Cover" SDS is the global map of snow cover extent for the eight day period. Extent of snow cover observed, expressed as percentage of land in the CMG cell, is given. Valid range of snow cover extent is 0-100%. Local attributes are given in Tables 4 and 29.

The "Eight_Day_CMG_Confidence_Index" SDS indicates how much of the land surface was observed. The greater the percentage of land observed the higher the confidence in the extent of snow. Cloud obstruction reduces the confidence index. Local attributes are given in Tables 4 and 30.

The "Eight_Day_CMG_Cloud_Obscured" SDS indicates how much of the land surface in the cell was persistently obscured during the eight-day period. Local attributes are given in Tables 4 and 31.

The "Snow_Spatial_QA" SDS indicates the overall quality of data in the CMG cell. This QA data is stored as a two bit flag. Local attributes are given in Tables 4 and 32.

Local Attributes

HDF predefined local attributes (Table 4) describe the structure and characteristics of the SDSs. Custom local attributes (Tables 29 - 33) are used to provide summary information on snow cover and other features in the CMG.

Table 29. Custom Local Attributes for the " Eight_Day_CMG_Snow_Cover " SDS

Attribute Name	Definition	Sample Value
_MaskValue	Value given to areas masked, from analysis; primarily oceans.	254
Cell_resolution	Approximate resolution of CMG cells.	0.05 degree
Water_Mask_Pct_Land_Threshold	Percentage of land in the cell to be processed as land.	12.00
Antarctic_snow_note	Special note on Antarctica processing.	"Antarctica deliberately mapped as snow."

Table 30. Custom Local Attributes for the " Eight_Day_CMG_Confidence_Index" SDS

Attribute Name	Definition	Sample Value
_MaskValue	Value given to areas masked, from analysis; primarily oceans.	254
_NightValue	Value assigned to cells in complete darkness.	111
Cell_resolution	Approximate resolution of CMG cells.	0.05 degree
Water_Mask_Pct_Land_Threshold	Percentage of land in the cell to be processed as land.	12.00
Antarctic_CI_note*	Special note on Antarctica processing.	"Antarctica deliberately mapped as snow. CI set to 100."

* confidence index (CI)

Table 31. Custom Local Attributes for the " Eight_Day_CMG_Cloud_Obscured " SDS

Attribute Name	Definition	Sample Value
_MaskValue	Value given to areas masked, from analysis; primarily oceans.	254

_NotProcessValue	Indicates that the cell was not processed.	252
_NightValue	Value assigned to cells in complete darkness.	111
Cell_resolution	Approximate resolution of CMG cells.	0.05 degree
Water_Mask_Pct_Land_Threshold	Percentage of land in the cell to be processed as land.	12.00
Antarctic_snow_note	Special note on Antarctica processing.	"Antarctica deliberately mapped as snow. Cloud set to 252."

Table 32. Custom Local Attributes for the " Snow_Spatial_QA" SDS

Attribute Name	Definition	Sample Value
_MaskValue	Value given to areas masked, from analysis; primarily oceans.	254
key	Explanation of the two bit QA flag.	"state of bits: 00=nominal, 01=suspect, 10=cloud obscured, 11=not analyzed"
Cell_resolution	Approximate resolution of CMG cells.	0.05 degree
Water_Mask_Pct_Land_Threshold	Percentage of land in the cell to be processed as land.	12.00
Antarctic_QA_note	Special note on Antarctica processing.	"Antarctica deliberately mapped as snow. Flag set to QAPERCENTNOTPRODUCEDOTHER."

Global Attributes

ECS global attributes of CoreMetadata.0, ArchiveMetadata.0 and StructMetadata.0 will have basically the same content, though there is some variation, as in the other snow products.

Table 33. *CoreMetadata.0* of the MOD10C2 data product.

Object Name	Sample Value	Comment
ShortName	"MOD10C2"	ESDT name of product
VersionID	1	ECS Version
ReprocessingActual	"processed once"	Number of times processed.
ReprocessingPlanned	"further update is anticipated"	Expect that products will be reprocessed one or more times.
LocalGranuleID	"MOD10C2.A2001033.001.20001268165647.hdf"	Name of the granule.
DayNightFlag	"Both"	
ProductionDateTime	"2001-09-25T16:56:47.000Z"	Time granule was produced.
LocalVersionID	"SCF V1.0.0.0"	Version of algorithm delivered from the SCF.
PGEVersion	"2.2.6"	Version of production generation executable in MODAPS.
InputPointer	"MOD10A2.A2001033…"	Names of input files. Typically 461 input files.
RangeBeginningDate	"2001-02-02"	Beginning and ending times of the first and last scan line in the swath.
RangeBeginningTime	"22:40:00.000000"	
RangeEndingDate	"2001-02-09"	
RangeEndingTime	"04:45:00.000000"	
EastBoundingCoordinate	180.000000	Extent of coverage of
WestBoundingCoordinate	-180.000000	

NorthBoundingCoordinate	90.000000	swath.
SouthBoundingCoordinate	-90.000000	
ParameterName	"Eight Day Global Snow Cover"	Parameter for which QA statistics are given in this metadata object.
AutomaticQualityFlag	"Passed"	Result of automated checks done on the data during a run of algorithm. Useful for screening for anomalous data.
AutomaticQualityFlagExplanation	"No errors detected in processing"	Explanation of result of automated QA checks made during execution.
QAPercentMissingData	1	Range of 0 - 100
QAPercentCloudCover	5	Range of 0 -100
AssociatedPlatformShortName	"Terra"	
AssociatedInstrumentShortName	"MODIS"	
AssociatedSensorShortName	"MODIS"	
Product Specific Attributes (PSA)		
QAPERCENTGOODQUALITY	91	Summary quality assurance statistic for data product. Range of 0 - 100.
QAPERCENTOTHERQUALITY	1	
QAPERCENTNOTPRODUCEDCLOUD	5	
QAPERCENTNOTPRODUCEDOTHER	3	

SNOWCOVERPERCENT	68	Summary percentage of snow-covered land. Range of 0 - 100.

The ECS global attribute ArchiveMetadata.0 contains information relevant to the input data, an alternate geographic coverage bounds, and information relevant to version of the algorithm and product. A listing of objects along with sample values is given in Table 13.

Table 34. *ArchiveMetadata.0* of the MOD10C2 data product.

Object Name	Sample Value	Comment
GlobalGridColumns	7200	
GlobalGridRows	3600	
AlgorithmPackageAcceptanceDate	"01-09-2001"	Algorithm Descriptors
AlgorithmPackageMaturityCode	"Stable"	
AlgorithmPackageName	"MOD_PR10C2"	
AlgorithmPackageVersion	"V 1.0.0"	
PlatformShortName	"Terra"	
ProcessingDateTime	"2001-09-25T12:56:13.000Z"	
LongName	"MODIS/Terra Snow Cover 8-Day L3 Global 5km CMG"	
ProcessingCenter	"MODAPS"	
SPSOParameters	"none"	
DESCRRevision	"1.2"	Version of MCF used.

The StructMetadata.0 global attribute is used by the HDF-EOS toolkit to create the mapping relationships between the defined grid and data (SDSs). Parameters of the projection are stored in StructMetadata.0.

Table 35. *StructMetadata.0* of the MOD10C2 data product.

Object Name	Sample Value
GRIDNAME	"MOD_CMG_Snow_5km"
PROJECTION	GCTP_GEO
DATAFIELD_1	"Eight_Day_CMG_Snow_Cover"

DATAFIELD_2	"Eight_Day_CMG_Confidence_Index"
DATAFIELD_3	"Eight_Day_CMG_Cloud_Obscured"
DATAFIELD_4	"Snow_Spatial_QA"

Other global attributes in the product are listed in Table 36.

Table 36. MOD10C2 product specific global attributes.

Attribute Name	Sample Value	Comment
HDFEOSVersion	"HDFEOS_V2.4"	Version of HDF_EOS toolkit.

Quality Assurance

The quality assurance flags set in bits 0 and 1 of the QA SDS indicate the condition of the input data. If all the input data was acceptable then setting is good (00). If some of the input data was suspect then the setting is other (01). If all the input was cloud obscured then the setting is cloud obscured (10). If analysis was not made on the cell or if it was masked from analysis then the setting is not produced (11). Since no other QA bit flags are set the QA data can easily be interpreted by integer value, the bits need not be read individually.

The oceans are excluded from analysis; ocean cells are identified as masked (value of 254) in the QA SDS.

Related Web Sites

EOS

1. Terra Website: http://terra.nasa.gov
2. ECS: http://ecsinfo.gsfc.nasa.gov
3. National Snow and Ice Data Center: http://nsidc.org

MODIS

4. MODIS Snow/Ice Global Mapping Project: http://modis-snow-ice.gsfc.nasa.gov
5. MODIS Project: http://modis.gsfc.nasa.gov
6. MODIS Land Discipline: http://modis-land.gsfc.nasa.gov
7. Cloud Mask (MOD35): http://cimss.ssec.wisc.edu/modis1/pdf/CMUSERSGUIDE.PDF

HDF-EOS Information and Tools

8. [EOSDIS](#): http://spsosun.gsfc.nasa.gov/ESDIShome.html

9. [HDF](#): http://hdf.ncsa.uiuc.edu

10. [HDF-EOS](#): http://hdfeos.gsfc.nasa.gov
    Note: Samples of HDF-EOS files can be obtained from this site.

11. [ECS Data Handling System](#): http://edhs1.gsfc.nasa.gov/

12. [Viewing HDF and HDF-EOS files](#): http://hdfeos.gsfc.nasa.gov/hdfeos/viewingHDFEOS.html

Earth Science

13. [GSFC Code 900 Earth Sciences Portal](#): http://farside.gsfc.nasa.gov/ESD/portal

Related Documents

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"The WMO Format for the Storage of Weather Product Information and the Exchange of Weather Product Messages in Gridded Binary Form", John D. Stackpole, Office Note 388, GRIB Edition 1, U.S. Dept. of Commerce, NOAA, National Weather Service National Meteorological Center, Automation Division, Section 1, pp. 9-12, July 1, 1994.

"The Michigan Earth Grid: Description, Registration Method for SSM/I Data, and Derivative Map Projections", John F. Galntowicz, Anthony W. England, The University of Michigan, Radiation Laborartory, Ann Arbor, Michigan, Feb. 1991.

"Selection of a Map Grid for Data Analysis and Archival", William B. Rossow, and Leonid Garder, American Meteorological Society Notes, pp. 1253-1257, Aug. 1984.

"Level-3 SeaWiFS Data Products: Spatial and Temporal Binning Algorithms", Janet W. Campbell, John M. Blaisdell, and Michael Darzi, NASA Technical Memorandum 104566, GSFC, Volume 32, Appendix A, Jan. 13, 1995.

"Key Characteristics of MODIS Data Products", E. Masuoka, A. Fleig, Robert E. Wolfe and F. Patt, IEEE Transactions on Geoscience and Remote Sensing, Vol 36(4), 1313-1323, July 1998.